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ABSTRACT

Content analysis of connected instructional discourse depends on the fundamental distinction between the content to be learned ("intrinsic") and the content intended only to support the learning processes ("mathemagenic"). Depending on the expected outcome of learning and the learner's entering competencies, the nature and amount of intrinsic and mathemagenic content vary. These two extrinsic factors influence content, its mode of presentation, and its sequence. Therefore, it can be concluded that instructional functions served by content are determined in critical ways by factors external to the content itself, and that content analysis can be appropriately accomplished only when these two factors are first identified. (MAI)

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Content as Related to Requirements of Instructional Design

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There appear to be many reasons for analyzing the content of collections of information that are organized basically as discourse or verbal communications. I assume we are concerned in this symposium with information organized in this way, which may of course also include pictures and symbolic expressions, and which is to be used for instruction. I assume, in other words, that subject-matter content means material organized into words and sentences, or representations of such words and sentences, which is communicated to a learner for the purpose of supporting the processes we call learning. Furthermore, I assume that in order to be called "subject-matter", the learning which such material supports must result in performance which can be shown to reflect directly the content of the material itself. In the simplest case, the learner who studies a paragraph about the removal of stains from clothing as a "subject-matter", can later indicate that he can tell us something about stain removal, or can show us something about stain removal, or both.

I need to say, perhaps, that it is not always apparent that those who write about "content structure" and "content analysis" always have this narrowly instructional purpose in mind. In a fine recent review of such efforts, for example, Gibbons (1977) makes a valiant try to identify the

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instructional implications of various proposed methods of content analysis. Although his success is notable, one cannot help but detect his between-the-lines perception of straying from this purpose by certain writers, particularly those who generate content which is vastly more complex than the content they propose to analyze. I shall try to stick to the point, which I conceive as how to relate content to the design of instruction.

A Fundamental Distinction

I should like to begin by re-emphasizing a distinction which has been made by a number of investigators. It was made with particular clarity by Merrill and Boutwell (1973), and I cited their work in a paper on task analysis prepared shortly thereafter (Gagné, 1974). Some portion of "content" is directly relatable to the performances that learning is designed to bring about. That is, some content is inherently relatable or intrinsic to the learning objective. Other portions, however, are related only to the support of learning processes, and are not to be themselves encoded and stored by the learner. These portions of content, as Merrill and Boutwell pointed out, have only a mathemagenic function, using Rothkopf's (1970) term.

In my article (1974), I pointed out that a given sentence might be either inherently relatable to a learning outcome, or it might be merely mathemagenic. The sentence "A tangent is a straight line which meets a curved line at a point, but does not cross it", might have a mathemagenic function in supporting the learning of the concept of a tangent. Alternatively, the sentence might be intrinsic to an expected learning outcome, if that outcome were "stating the definition of a tangent". Of course, such a sentence might serve both functions, if both these outcomes were

expected. But it does not necessarily serve both functions, and I believe these can and should be distinguished. I should like to deal further with intrinsic content and mathemagenic content.

Basic Considerations in Instructional Design

Let me turn first to some considerations of instructional design. What features of a situation which is intended to bring about learning in a student does the instructional designer typically take into account? The important features are, I think, as follows:

(1) First, of course, is the expected outcome of the learning, sometimes called the objective.

(2) Second, the designer must consider the beginning state of the learner - the learner's entering competencies or entering capabilities.

(3) Third, there is the matter of the mode of presentation of the instructional events - whether in auditory speech, printed words, pictures, scenes, or some combination of these.

(4) Fourth is what is called content - the actual composition of the communications or other stimuli that are to be delivered to the learner.

(5) And fifth is the question of the arrangement or ordering of this stimulation, or what is sometimes called the sequencing of content.

Now, of course, these aspects of instructional design are by no means independent. Rather, they are strongly interdependent, as a couple of simple examples will show. Content which is designed to be relevant for the learning of skills such as a golf stroke or a backhand tennis stroke must surely be different, on the whole, from content designed to support the learning of, say, knowledge of the constitutional checks and balances which exist between the U.S. Congress and the Supreme Court. The expected

outcome of the learning influences the content. As a second example, content designed to teach a third grade student how to interpret the label of a bottle of medicine must surely be different from content having the same objective for a high school student. The beginning state of the learner influences content.

I should like to continue to examine some of the interrelationships of these factors in instructional design, taking into account the distinction between mathemagenic portions and intrinsic portions.

The Influence of Expected Outcomes of Instruction

The outcomes expected of a learner exert influences on instructional content which carry different implications for the mathemagenic portions and for the intrinsic portions.

Outcome: stating information. Suppose that the intended outcome is for the student to state the information centering about the general question, "What check does Congress have on the Supreme Court?" One of the expected items of information, for example, might be a paraphrased statement from Article III, Section 2 of the U.S. Constitution, which states that the Court shall have appellate jurisdiction "with such exceptions, and under such regulations as the Congress shall make."

What is notable about this type of outcome, however, is that while it may indeed be expected, it is only a small part of what is expected. Were a learner to be able to state his knowledge only in this way, his teachers would be highly dissatisfied. They would accuse the learner of "memorizing" some highly specific item. In fact, what is expected is a great deal more information. Why was this "check" inserted in the Constitution? Can it be interpreted in more than one way? Has such a check ever been imposed? Why was it imposed, and what are some examples?

When did Congress use such a check? What was the reaction of the Court?

In other words, when we say a student is learning facts about constitutional checks and balances, we are not satisfied that he has learned them unless indeed he can state a great many related facts - a whole network of facts. Otherwise, we believe he does not display "understanding" of what he can tell us.

Outcome: using a rule. As a contrast, suppose a student is expected to learn a rule about the length of a hypotenuse of a right triangle - a rule formulated by Pythagoras. In this case, we are convinced that he has learned the rule when he can find two or three hypotenuses of different right triangles, newly presented. If he can do this, we do not accuse him of "memorizing" the rule; rather we tend to be highly satisfied that he does indeed understand it. But note that we do not in this case expect him to tell us about other kinds of triangles, or about what else Pythagoras did, or about how he happened to find this relationship, or about a host of other facts or rules that may be in some way related to this single rule of Pythagoras.

The general point to be made is that in this case, when the expected outcome is the performance of applying a rule, the context which surrounds the communication of the rule itself has a mathemagenic function, and not an intrinsic one. This is in sharp contrast to the instance of learning verbal knowledge, where the content is largely intrinsic to what must be learned, and contains only a small mathemagenic component.

Outcome: acquiring an attitude. Still a third example of an outcome may be used to illustrate this point - namely, the acquiring of, or the modification of, an attitude. We know from studies of "communication and persuasion" that many kinds of content have been investigated

with reference to their effectiveness in changing attitudes. Content aimed at attitude change may consist of rational arguments for and against a point of view, emotional appeals, persuasive discourse, and a number of other types. Does this content serve an intrinsic function? Obviously not. We do not expect the learner to be able to store and recall the rational arguments or the content of the emotional appeals when we are seeking a change in an attitude.

Does content of this type then have a mathemagenic function? To some minor extent, perhaps it does. If so, however, it is not particularly effective, as many studies have shown (Hovland, Janis, and Kelley, 1953). We cannot expect attitudes to be changed in the direction that would be indicated by an analysis of content alone. The same studies indicate again and again that the significant mathemagenic variable is the source, rather than the message. In the case of attitude learning, then, we again encounter a kind of outcome in which content has no intrinsic function, in contrast to the situation which obtains in the learning of verbal knowledge. Even the mathemagenic function of such content appears to be playing a minor role, except to the extent that it may convey to the learner a representation of the "source", which I assume to be a human model.

The Influence of the Learner's Entering Capabilities

The effect upon learning outcomes of what the learner has already learned - his "entering competencies" - has been demonstrated in many kinds of research studies. As examples, I cite the evidence described by Bloom (1976) in his recent work, Human Characteristics and School Learning; the evidence in research on learning hierarchies regarding the

role of prerequisites in the learning of intellectual skills (White and Gagné, 1974); and the findings of Ausubel (1968) on the process of subsumption.

How should all such evidence be interpreted in relation to the question of content and content analysis? The answer appears to be, stated in its most general form, that the design of content for effective learning must be critically influenced by the learner's entering capabilities, by what he brings to the new learning situation from his memory store. Perhaps it would be difficult to find disagreement with this general proposition. However, it is notable again that the influence of this factor on content differs in respect to the intrinsic and the mathemagenic function the content is designed to serve.

When new verbal knowledge is to be learned, the mathemagenic function of content is, according to Ausubel's (1968) view of an advance organizer, to arouse a pre-existing cognitive structure containing a relevant "anchoring idea." Alternatively, following Rothkopf's (1970) view, one can conceive the function of certain inserted statements or questions as having the mathemagenic function of establishing a general set or attentional habit. With either of these conceptions, what is notable is that one does not have to specify exactly what previous capabilities the learner must have. The content, in its mathemagenic function, does not have to take account of what previous content has been stored, in any precise manner. In order to learn new verbal knowledge about the mining of coal, the relation of the advance organizer may be to a larger meaningful structure about the nature of minerals, or it could be about mining, or even about forms of energy. Similarly,

if one considers the mathemagenic function of inserted questions, they could be about names, or dates, or some other general category, but they need not specify particular names or dates; in fact, they should not. In general, when verbal knowledge is being learned, mathemagenic content is designed to make contact with some memorial content which itself has a mathemagenic function.

When a new intellectual skill, such as a rule, is being learned, the function of content is different. What must be available from the learner's memory is specific capabilities which are themselves intrinsic to the outcome. To use an example from White's (1973) work, the learner who is expected to find velocity from a position-time graph must have available the intrinsic content of prerequisite skills, an example of which is finding the slope of a straight line. The content for such a learner, then, must have the function of either (1) stimulating the recall of intrinsic content (a mathemagenic function) or (2) providing the specific intrinsic content of the prerequisite skills.

General Conclusions

What I have tried to show by these remarks is that the functions served by content are determined in critical ways by factors external to the content itself. In particular, these factors are the intended outcome of the learning, and the state of the learner's entering capabilities. These factors influence both the mathemagenic component and intrinsic component that content has. Such functions of content vary with respect to what is being learned, whether verbal knowledge, intellectual skills, attitudes, or other intended outcomes. And they tie into the learner's previously acquired capabilities in ways which interact with these intended outcomes. I am inclined to believe, therefore,

that the content itself, as well as the mode used for its presentation, and the sequence with which it is presented, are all substantially influenced by these external considerations.

Can subject-matter be analyzed to provide indications of good instructional design? Surely it can. But one should not expect, by such analysis, to find general principles which are independent of the extrinsic factors of intended learning outcomes and entering learner competencies. These are the fundamental determinants of subject-matter, and outweigh in importance for learning the precise nature of the content itself, as well as its mode and sequence of presentation.

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